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THE INFLUENCE OF SOIL DIFFERENTIATION ON CHEMICAL COMPOSITION OF SEA BUCKTHORN (*HIPPOPHAË RHAMNOIDES* L.) LEAVES AS FEED MATERIAL

WPŁYW ZRÓŻNICOWANEJ ZASOBNOŚCI GLEBY NA SKŁAD CHEMICZNY LIŚCI ROKITNIKA ZWYCZAJNEGO (*HIPPOPHAË RHAMNOIDES* L.) JAKO MATERIAŁU PASZOWEGO

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Streszczenie. Ponieważ liście rokitnika mogą być materiałem stanowiącym uzupełnienie pasz oraz innych produktów spożywczych, przeprowadzone badania miały na celu określenie zawartości w liściach takich pierwiastków chemicznych, jak: azot, fosfor, potas, wapń, magnez, żelazo, mangan, cynk, ołów, kadm, nikiel i miedź, jak również określenie zależności między ich ilością a zasobnością gleby. Krzewy dziko rosnącego rokitnika *(Hippophae rhamnoides* L. *ssp. Rhamnoides),* z których w czerwcu 2014 roku pobrano liście, zlokalizowane były w czterech miejscach na terenie Szczecina. Z otrzymanych danych, dotyczących zawartości makro- (N, P, K, Ca, Mg) i mikroskładników (Fe, Mn, Zn, Ni, Cu, Pb, Cd) w liściach dziko rosnącego rokitnika (*Hippophae rhamnoides* L.), wynika, że mogą stanowić dobry materiał paszowy porównywalny z trawami i roślinami motylkowatymi. Nieprzekraczająca dopuszczalnych norm zasobność liści dziko rosnącego rokitnika (*Hippophae rhamnoides* L.) w ołów i kadm stanowi kolejny argument potwierdzający przydatność tej rośliny jako materiału paszowego.

Key words: *Hippophaë rhamnoides* L., macronutrients, micronutrients, soil.
Słowa kluczowe: *Hippophaë rhamnoides* L., makroskładniki, mikroskładniki, gleba.

INTRODUCTION

Sea buckthorn (*Hippophaë rhamnoides* L.) belongs to the olive plants family (*Elaeagnaceae).* It is also sometimes referred to as Russian pineapple. Sea buckthorn was first described in Tibetan medical books dating back to 18th century.

In ancient Greece sea buckthorn was fed to horses in order for them to have shiny coats and that is where the genus name comes from: ‘hipp’ – a horse, ‘phaos’ – shiny. In the beginning of XX century there were seven species distinguished. Sea buckthorn grow in Europe and Asia, including China, however, its greatest diversity is observe in the region of Tibet and Qinghai province (Suryakumar and Gupta 2011).

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Sea buckthorn is an Eurasian plant, but it is Asia where it acquired the widest occurrence range. Its occurrence in Europe is relatively small in compared to the East. There are two subspecies of sea buckthorn distinguished: *Hippophae rhamnoides* subsp. *maritima,* which is characteristic for *Salicion arenarieae* in the classification of plant communities plant communities and *Hippophae rhamnoides* subsp. *rhamnoides*, which is a thorny shrub with raised stiff branches and dense inflorescences. It is a characteristic shrub of sand dunes and dune valleys on the sandy coasts of the Northern Sea and the Baltic Sea (Dulf 2012). In Poland it can be found on rocky hillsides, sandy coastal cliffs, dry river valleys, gravel pits, bright pine forests or road slopes.

The increase of the interest in sea buckthorn is associated with the possibility of its introduction onto fallow lands and industrial areas as well as forests due to its beautiful and valuable fruit, which possess high nutritional and pro-health properties. The fruit contain high quantities of C and E vitamins, some of the B vitamins and provitamin A, as well as organic acids and free amino acids (Ahmad and Ali 2013; Lācis and Kota-Dombrovska 2014). The fruit juice contains 24 elements including nitrogen, phosphorus, iron, manganese, boron, calcium and silicone. The fruit flesh and seeds contain even 12% of oil, which is rich in palmitic, myristic, stearic, oleic, linoleic and linolenic acids (Yang and Kallio 2006; Alam and Ijaz 2009; Pop et al. 2014). Additionally, the fruit also contain carotene, flawonoids and alkaloids (Zadernowski et al. 2005; Fatima et al. 2012; Giuffrida et al. 2012; Magnuszewska and Krogulec 2013; Tulsawani et al. 2013). Zeb and Malook (2009) emphasize that all parts of sea buckthorn are good sources of high quantity bioactive substances. Sea buckthorn leaves can be a valuable supplement for animal feed as well as food products. Grey-green leaves of the bushes are delicate and decorative, the leaves are arranged spirally, they are lanceolate and narrow and have short stalks. They have smooth edges and are covered with soft, silvery hair, grey-green on the top side and silvery at the bottom side. The leaves are up to 7 cm long and 1 cm wide and have slightly curved edges (Suryakumar and Gupta 2011). In their research on six different sea buckthorn varieties from the Carpathia Mountains (*Hippophae rhamnoides* L. *ssp. carpatica*) Pop et al. (2014) discovered that the total carotenoids in leaves ranged between 3.5 and 4.2 mg $\cdot$ 100 g^{-1} DM. They included lutein, β-carotene, violaxantine and neoxanthin.

Several studies conducted in India and China indicated that aqueous extracts derived from dried sea buckthorn leaves contain significant quantities of anti-oxidants, which exhibit immunomodulatory and anti-inflammatory properties, as well as phenols (Saggu et al. 2007; Saini et al. 2010; Kumar et al. 2011; Zheng et al. 2012). Kim et al. (2010) applied 10 and 20% powdered sea buckthorn leaves in the diet of diabetic mice and observed a decrease in glucose blood level and cholesterol levels. Heinäaho et al. (2006) studied the influence of various cultivation methods on the content of phenol compounds in leaves of sea buckthorn seedlings (*Hippophae rhamnoides* L. *ssp. rhamnoides*) in western Finland and found that a cultivation method influenced the content of valuable compounds in the leaves: gallic acid, pentagalloylglucose, quercetin, monocoumaroyl astragaline. Available data indicate a diverse chemical composition of sea buckthorn leaves, but they mainly concentrate on bioactive substances and their influence on living organisms. Obtaining of natural agents requires a thorough knowledge on the chemical composition of the tested plants.

Due to the fact that sea buckthorn leaves could be a supplement to animal feed and food products, the present research aimed to determin the content of such elements as nitrogen, phosphorus, potassium, calcium, magnesium, iron, manganese, zinc, lead, cadmium, nickel and copper in sea buckthorn leaves as well as establishing of the relation between the elements content and soil composition.

MATERIAL AND METHODS

The leaf samples were collected in June 2014 from wild sea buckthorn shrubs *(Hippophae rhamnoides* L*. ssp. rhamnoides)* localised in four sample in Szczecin (53º42′ N, 14º58′ S), Poland. The soils in which the shrubs grew had similar pH and were all alkaline. Detailed description is presented in Table 1. The soil's pH_{KCl} was determined potentiometrically. The amount of organic carbon was determined through oxidation with dichromate(VI) in sulphuric acid(VI). The content of organic matter was assessed through multiplying the organic carbon amount by 1.724 coefficient.

Table 1. Characteristics of soil with different samples
Tabela 1. Charakterystyka gleby z różnych miejsc

Sample Próba	pH_{KCl}	Organic carbon Węgiel organiczny [g · kg^{-1} DM]	Organic matter Masa organiczna [g · kg^{-1} DM]	Characteristics of soil Charakterystyka gleby
1	7.32	16.5	28.4	sandy soil using reclaimed coal ash + NPK 60 – 70 – 70 + + sewage sludge in a ratio 1 : 1 gleba piaszczysta rekultywowana z zastosowaniem popiołu z węgla kamiennego z NPK 60 – 70 – 70 + osad ściekowy, w proporcji 1 : 1
2	7.59	15.4	26.5	sandy soil using reclaimed coal ash + bark of conifers + + compost from sewage sludge. in a ratio 1 : 2 : 4 gleba piaszczysta rekultywowana z zastosowaniem popiołu z węgla kamiennego + kora z drzew iglastych + kompost z osadów ściekowych w proporcji 1 : 2 : 4
3	7.76	6.1	10.5	sandy native soil gleba piaszczysta rodzima
4	7.49	12.9	22.2	sandy soil on the banks of the Odra River gleba piaszczysta nad brzegiem rzeki Odry

Nitrogen was determined in the solutions derived from mineralization of the soil and plant samples in sulphuric acid(VI) with H_2O_2 – Kjeldahl's method. The content of exchangeable phosphorus and potassium was established by Egner-Riehm method (Egner et al. 1960). Extraction with buffered barium chloride solution (pH = 8.1) was applied in order to determine replaceable forms of magnesium and calcium content in the soil.

Total elements (K, Ca, Mg, Fe, Mn, Zn, Pb, Cd, Ni and Cu) were determined in the soil and leaves after wet burning in a mixture of nitric(V) and chloric(VII) acids. The analyses were conducted using an Absorption Spectrometer apparatus (Thermo Fisher Scientific ICE 3000 Series). Phosphorus was determined calorimetrically with ammonium molybdate, at wavelength 470 nm.

The statistical analysis of the results was conducted using Statistica 10 software. In order to determine the significance of the differences in chemical composition of the analysed soil and plant samples one way analysis of variance (ANOVA) was conducted. For the purpose of determining homogenous subsets of means the Newman-Keulus test was carried out at $p \leq 0.05$.

RESULTS AND DISCUSSION

Macronutrients

Macronutrients are directly associated with most of the metabolic processes in plants. Their content in soil determines yields, plants' resistance to diseases and their chemical composition.

Nitrogen

In their arable layer most soils in Poland the nitrogen content ranges between 0.1 and 30 g N · kg^{-1} DM. (Kabata-Pendias 2011). The nitrogen content in the soils at the sample collection was variable, but the values fell within the described range (Table 2). The chemical composition analyses of sea buckthorn (*Hippophae rhamnoides* L.) leaves implicate that they are comparable with the composition of legume plants, which are main fodder plants cultivated in Poland and used in highly nutritious animal feed. Total nitrogen in these plants equals ca. 30 g N · kg^{-1} DM. (Gaweł 2011). Different nitrogen content in the soils on which wild sea buckthorn grew did not find its reference in nitrogen content in leaves. The leaves of the shrubs growing on the nitrogen-richest soil only contained 36.26 g N · kg^{-1} DM (Table 2 and 3).

Table 2. The content of macronutrients in soil sampled from the wild sea buckthorn shrubs
Tabela 2. Zawartość makroskładników w glebie pobranej spod dzikich krzewów rokitnika

Sample Próba	Total nitrogen N_{tot} Azot całkowity $N_{cał}$	Exchangeable phospohorus $P_{exchang}$ Fosfor przyswajalny P_{przys}	Exchangeable potassium $K_{exchang}$ Potas przyswajalny K_{przys}	Replaceable calcium Ca_{repl} Wapń wymienny $Ca_{wymienny}$	Replaceable magnesium Mg_{repl} Magnez wymienny $Mg_{wymienny}$
	g · kg^{-1} DM	mg · kg^{-1} DM			
1	2.78^{d}	116.0^{d}	318.0^{d}	2899.5^{c}	798.3^{c}
2	1.61^{c}	80.9^{c}	231.5^{c}	3336.6^{d}	415.7^{b}
3	0.40^{a}	37.4^{b}	57.5^{b}	1021.4^{b}	64.7^{a}
4	0.86^{b}	24.8^{a}	46.3^{a}	306.2^{a}	56.1^{a}
Mean Średnia	1.41	58.6	163.3	1890.9	333.7

Mean values with the same letter in each column are not significantly different at $p \leq 0.05$.
Średnie wartości w kolumnie oznaczone tymi samymi literami nie różnią się istotnie przy $p \leq 0,05$.

Table 3. The content of macronutrients in leaves from the wild sea buckthorn shrubs
Tabela 3. Zawartość makroskładników w liściach z dzikich krzewów rokitnika

Sample Próba	Nitrogen Azot N	Phospohorus Fosfor P	Potassium Potas K	Calcium Wapń Ca	Magnesium Magnez Mg
	g · kg^{-1} DM				
1	36.26^{a}	3.67^{a}	14.00^{d}	3.39^{a}	2.48^{a}
2	42.35^{b}	3.90^{a}	10.43^{b}	4.56^{c}	2.87^{a}
3	44.52^{c}	3.77^{a}	12.75^{c}	5.99^{d}	2.60^{a}
4	35.49^{a}	3.65^{a}	8.98^{a}	4.17^{b}	2.63^{a}
Mean Średnia	39.65	3.74	11.54	4.53	2.64

Mean values with the same letter in each column are not significantly different at $p \leq 0.05$.
Średnie wartości w kolumnie oznaczone tymi samymi literami nie różnią się istotnie przy $p \leq 0,05$.

Exchangeable phosphorus

The content of exchangeable phosphorus in the analysed soils ranged between 24.8 and 116.0 mg P · kg^{-1} DM. (Table 2). However, it did not influence the phosphorus content in leaves of sea buckthorn growing on them, which similar level from 3.65 to 3.90 g P · kg^{-1} DM. (Table 3). Kulik (2009) analysed the influence of phosphorus fertilisation on changes in phosphorus content in sward consisting of grass and legumes and found that these plants contain between 3.4 and 4.3 mg P · kg^{-1} DM, which is analogical to sea buckthorn leaves.

Exchangeable potassium

In the analysed soils the content of exchangeable potassium was variable and ranged from 46.3 to 318.0 mg K · kg^{-1} DM. This fact found its reference in potassium content in sea buckthorn leaves, which ranged from 8.98 to 14.00 K · kg^{-1} DM (Table 2 and 3). According to Jankowska-Huflejt (2014) the threshold value of potassium content in animal feed equals 8.3 g K · kg^{-1} dry matter. Therefore, wild sea buckthorn leaves should be treated as an appropriate animal feed substrate.

Replaceable calcium and magnesium

Application of coal ash in two of the studied sample caused them to have few times higher amounts of replaceable forms of magnesium and calcium than the remaining two soils. Total calcium and magnesium in sea buckthorn (*Hippophae rhamnoides* L.) leaves were not dependent on their content in soil (Table 2 and 3).

The range of calcium occurrence in fodder plants is wide, from 1 to 43 g Ca · kg^{-1} DM and the limit range of magnesium content equals 2 g Mg · kg^{-1} DM (Kulik 2009). Calcium and magnesium contents in the studied wild sea buckthorn (*Hippophae rhamnoides* L.) leaves ranged from 3.39 to 5.99 g Ca · kg^{-1} DM (Table 3) and from 2.48 to 2.87 g Mg · kg^{-1} DM, respectively. These values qualify sea buckthorn as a fodder plant.

Micronutrients

(Fe, Mn, Zn, Ni, Cu, Pb, Cd) are elements occurring in trace quantities in soil. Their concentration is a hundred to a thousand times smaller than macronutrients, but they remain very important factors in growth and development of plants. Micronutrients are mainly catalysts of physiological processes in plants.

Iron and manganese

Iron is the most common trace element. Most of iron is contained in soil minerals. Iron content in soils in Poland ranges from 8.0 to 18.0 g Fe in 1 kg of soil (Kabata-Pendias 2011). Analogically, reclaimed soil, after application of coal ash, had total iron ranging from 9.26 to 18.06 g Fe · kg^{-1} DM (Table 4). Sandy soil however, had lower iron content, ranging from 3.93 and 5.35 g Fe · kg^{-1} DM. Variable content total iron in soils was not reflected in the element content in sea buckthorn leaves (*Hippophae rhamnoides* L.). The mean iron level in leaves was 163.08 mg Fe · kg^{-1} DM (Table 5). Dospatliev et al. (2014) showed that the optimum iron content in tobacco leaf is 50 to 300 mg · kg^{-1}. Such quantity of iron is also characteristic for grassland or legume plants (Jeroch et al. 1993).

Table 4. The content of micronutrients in soil sampled from the wild sea buckthorn shrubs
Tabela 4. Zawartość mikroelementów w glebie pobranej spod dzikich krzewów rokitnika

Sample Próba	Iron Żelazo Fe	Manganese Mangan Mn	Zinc Cynk Zn	Nickel Nikiel Ni	Cooper Miedź Cu	Lead Ołów Pb	Cadmium Kadm Cd
	mg · kg^{-1} DM						
1	9.68	216.05^{c}	108.35^{d}	57.44^{a}	36.23^{d}	20.74^{a}	4.35^{b}
2	18.06^{d}	280.45^{d}	53.08^{b}	58.20^{a}	25.30^{c}	18.56^{a}	4.45^{b}
3	3.93^{a}	80.34^{a}	16.52^{a}	16.46^{b}	2.69^{a}	6.78^{b}	3.81^{a}
4	5.35^{b}	100.69^{b}	88.59^{c}	20.13^{c}	13.61^{b}	58.27^{c}	3.81^{a}
Mean Średnia	9.26	169.38	66.63	38.06	19.46	26.09	4.10

Mean values with the same letter in each column are not significantly different at $p \le 0.05$.
Średnie wartości w kolumnie oznaczone tymi samymi literami nie różnią się istotnie przy $p \le 0,05$.

Table 5. The content of micronutrients in leaves from the wild sea buckthorn shrubs
Tabela 5. Zawartość mikroelementów w liściach z dzikich krzewów rokitnika

Sample Próba	Ratio Stosunek Fe : Mn	Iron Żelazo Fe	Manganese Mangan Mn	Zinc Cynk Zn	Nickel Nikiel Ni	Cooper Miedź Cu	Lead Ołów Pb	Cadmium Kadm Cd
		mg · kg^{-1} DM						
1	7.6	111.77^{a}	14.69^{a}	25.63^{c}	2.94^{a}	7.58^{b}	0.83^{b}	0.94^{a}
2	6.1	156.75^{c}	25.85^{b}	17.65^{a}	4.53^{a}	7.01^{a}	1.49^{c}	0.79^{a}
3	2.9	151.36^{b}	51.86^{d}	21.47^{b}	4.54^{b}	8.65^{c}	1.83^{d}	0.78^{a}
4	7.4	232.44^{d}	31.52^{c}	27.55^{d}	2.94^{b}	13.11^{d}	0.27^{a}	0.72^{a}
Mean Średnia	6.0	163.08	30.98	23.07	3.74	9.09	1.10	0.81

Mean values with the same letter in each column are not significantly different at $p \le 0.05$.
Średnie wartości w kolumnie oznaczone tymi samymi literami nie różnią się istotnie przy $p \le 0,05$.

Manganese is important in the process of photosynthesis and respiration. It is abundant in sandy soils (20–5000 mg in 1 kg of soil) – Kabata-Pendias (2011). It is an element with no determined acceptable threshold values in soil characteristics. Coal ash was applied in the samples 1 and 2 and it caused twice as high manganese content in these soils than in natural soil. Increased manganese in reclaimed soil did not influence its content in wild sea buckthorn (*Hippophae rhamnoides* L.) leaves. Similar results were obtained by Wilkins (1979), who determined manganese content in arable layer of soil in North West Pembrokeshire and observed no correlation between gathered results and content in plants growing there. Manganese content in leaves ranged from 14.69 to 51.86 mg Mn · kg^{-1} DM (Table 4 and 5). Jeroch et al. (1993) reported that intensely fertilised grassland weeds contain 130 mg Mn · kg^{-1} DM. As long as manganese content is concerned sea buckthorn leaves are not disqualified as animal feed material.

Iron in plants is found at second and third oxidation level. Manganese is found at various oxidation levels, from second through the third and fourth a plus seventh. Under specific conditions total cations in a plant not change significantly. An increase in uptake of one of the elements caused a decrease in uptake of the other ones. In the present context it is worth mentioning that manganese and iron could act as biochemical antagonists and compete for their absorption from soil by binding enzymes (Gudmundsdóttir et al. 2006).

The descried elements are present in plants at various oxidation levels, therefore in order to compare their content, only weighting ratios could be calculated as simple quotients of their amount in plants (Table 5). Fe : Mn ratio in wild sea buckthorn (*Hippophae rhamnoides* L.) leaves was in ranged from 2.9 : 1 to 7.6 : 1, which indicated higher iron than manganese concentration. According to Adriano (2001) Fe : Mn ratio in healthy plants in animal feed should was in range from 1.5–2.5 : 1. Below the value of 1.5 signs of manganese toxicity and iron deficiency were observed, whilst the value exceeding 2.5 caused excess iron to be toxic and manganese deficiency was reported. In order to increase quality of sea buckthorn – based animal feed the leaves should be supplemented with material containing easily-assimilable manganese. Considerable abundance of iron and manganese deficiency can be explained by the lower solubility of manganese than iron salts and the fact that the analysed plants usually grew in relatively dry areas.

Zinc

In contrast to cadmium and lead, zinc is an element essential in metabolism regulating processes in living organisms. Total zinc in light soils ranges from 7 to 150 mg Zn · kg^{-1} of soil (Kabata-Pendias 2011). The amount of zinc in the soils at the four examined samples ranged from 16.52 to 108.35 mg Zn · kg^{-1} DM. and despite the measures taken for the rehabilitation of the ash from coal the limits for Polish soils were not exceeded (Table 4). The various zinc content in the soils, where wild sea buckthorn was collected, was not reflected in zinc content in leaves. Leaves wild sea buckthorn (*Hippophae rhamnoides* L.) contained from 17.65 to 27.55 g Zn · kg^{-1} DM (Table 5). Jeroch et al. (1993) reported that intensively fertilised grassland plants contained 30 mg Zn · kg^{-1} DM. Therefore, the abundance of wild sea buckthorn leaves (*Hippophae rhamnoides* L.) with respect to zinc confirms the suitability of the plant as a feed material.

Nickel

Nickel is an element essential for some of the physiological processes in plants, it plays an important role in regulation of free nitrogen assimilation in soil bacteria. Nickel content in reclaimed soils (samples 1 and 2) was equal 57.44 and 58.20 mg Ni · kg^{-1} of soil and it is an amount twice lower than the acceptable norm (DzU 2002, no. 165, 1359). Natural sandy soil (samples 3 and 4) contained less nickel (16.46 and 20.13 mg Ni · kg^{-1} DM). These values did not exceed the average nickel content for light soils (8–33 mg Ni · kg^{-1}). An increased nickel levels in reclaimed soils in the samples, where wild sea buckthorn (*Hippophae rhamnoides* L.) was collected did not increase the content of this element in leaves. They contained between 2.94 to 4.54 mg Ni · kg^{-1} DM (Table 5). Kabata-Pendias (2011) reported that nickel content in grass ranged from 0.3 to 4.7 mg · kg^{-1} d. m., and in legume plants from 0.2 to 8.2 mg · kg^{-1} DM, respectively. According to this, leaves of wild sea buckthorn can be treated as an appropriate animal feed material.

Copper

The acceptable copper content in light soils is 150 mg · kg^{-1} DM (DzU 2002, no. 165, 1359). Soil reclamation increased the amount of this element in it (samples 1 and 2), which was caused by high copper levels in the used coal ash. However, the threshold value was not exceeded in none of the examined samples (Table 4). Natural sandy soil (samples 3 and 4) had lower copper content (2.69 and 13.61 mg Cu · kg^{-1} DM). The amount of copper in the examined wild sea buckthorn (*Hippophae rhamnoides* L.) leaves did not reflect copper content in the soils (Table 4 and 5).

The observed results showed a reverse relationship: copper content was lower in plants growing on the soil rich in this element. Copper content ranged from 7.01 to 13.11 g Cu · kg^{-1} DM (Table 5), which falls within the limits for grass (2.2 to 21.0 mg · kg^{-1} DM) and legumes 4.2 to 20.9 mg Cu · kg^{-1} DM (Kabata-Pendias 2011). According to accepted regulations the amount covering animals needs for copper is 10 mg Cu in kg DM of feed. The obtained results indicated that sea buckthorn leaves are an appropriate animal feed material.

Lead and cadmium

Institute of Soil Science and Plant Cultivation analyses showed that natural lead content in soils in Poland does not exceed 20 mg Pb · kg^{-1}. Soil reclamation increased their lead levels (samples 1 and 2), which resulted from lead content in the used coal ash. Natural sandy soil in the sample 3 only contained 6.78 mg Pb · kg^{-1} DM. The fourth sample was localised close to a road, which resulted in high lead content in soil (58.27 mg Pb · kg^{-1}). Despite this, the threshold value of 100 mg Pb · kg^{-1} of soil (DzU 2002, no. 165, 1359) was not exceeded in none of the samples (Table 4). A confirmation of these results can be found in data presented by Wilkins (1979), who determined lead concentration in soils collected at 2 km distance from A5, A6 and M1 roads in Rothamsted Experimental Facility and found an increase ranging from 17 to 46% of lead in soil. Lead content in plants collected twice a year did not increase significantly. The accepted treshold amount of cadmium equals 4 mg Cd · kg^{-1} of soil (DzU 2002, no. 165, 1359). It was exceeded in the soils in the samples 1 and 2, where reclamation was conducted. However, the differences between obtained values were not statistically significant and the amounts constitute a homogenous group (4.35 and 4.45 g Cd · kg^{-1}). Natural sandy soil in the other samples contained the same amount of cadmium (3.81 g Cd · kg^{-1}), which fell within the accepted boundaries (Table 4). The European Commission's regulation (2013) concerning the maximum cadmium and lead content in animal feed, determined the accepted amounts of these elements in feed. The amount of lead should be lower than 10 mg Pb · kg^{-1} dry matter and the amount of cadmium should not exceed 1 mg Cd · kg^{-1} (Commission Regulation 2013).

Lead is easily absorbed by plants and stored in their tissues. Lead content in wild sea buckthorn (*Hippophae rhamnoides* L.) leaves ranged from 0.27 to 1.83 mg · kg^{-1} DM. The various lead content in soils of different samples was not reflected in its content in the leaves. Reversely, the leaves growing plants on lead-richest soils had the smallest element content (0.27 mg Pb · kg^{-1} DM).

Cadmium is similar to zinc in their chemistry, but in contrast to zinc, it is not a biologically essential element. Assessment of cadmium content in sea buckthorn (*Hippophae rhamnoides* L.) leaves and statistical analyses did not reveal its significant variation. Its content narrow ranged from 0.72 to 0.94 mg Cd · kg^{-1} DM (Table 5).

The fact that lead and cadmium in wild sea buckthorn (*Hippophae rhamnoides* L.) leaves do not exceed the accepted norms for these elements is an another argument confirming its usefulness as an animal feed material.

CONCLUSIONS

1. Nitrogen, phosphorus, calcium and magnesium content in the wild sea buckthorn (*Hippophae rhamnoides* L.) leaves did not reflect their content in soil. The increased levels of macronutrients in soil did not increase its content in the plant.

2. The analyses of the wild sea buckthorn leaves revealed that the amount of potassium was depend on its content in soil.
3. Various content of micronutrients in soil did not cause an unequivocal increase in their content in leaves of wild sea buckthorn.
4. The data concerning the content of macronutrients (N, P, K, Ca, Mg) and micronutrients (Fe, Mn, Zn, Ni, Cu, Pb, Cd) in leaves of wild sea buckthorn indicate that the leaves can be considered to good animal feed material, comparable to grass and legumes.
5. The fact that content of lead and cadmium in wild sea buckthorn leaves do not exceed the accepted norms for these elements is an another argument confirming its usefulness as an animal feed material.

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Abstract. Due to the fact that sea buckthorn leaves could be a supplement to animal feed and food products, the present research aimed at determining the content of such elements as nitrogen, phosphorus, potassium, calcium, magnesium, iron, manganese, zinc, lead, cadmium, nickel and copper in sea buckthorn leaves as well as establishing the relation between the elements content and soil composition. The leaf samples were collected in June 2014 from wild

sea buckthorn shrubs (*Hippophae rhamnoides* L. *ssp. rhamnoides*) localised in four spots in Szczecin Poland. The data concerning the content of macronutrients (N, P, K, Ca, Mg) and micronutrients (Fe, Mn, Zn, Ni, Cu, Pb, Cd) in leaves of wild sea buckthorn (*Hippophae rhamnoides* L.) indicate that the leaves can be considered good animal feed material, comparable to grass and legumes. The fact that content of lead and cadmium in wild sea buckthorn leaves do not exceed the accepted norms for these elements is an another argument confirming its usefulness as an animal feed material.